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THE TREND OF MORPHOLOGY[1]

THE trend of morphological investigation has seemed to me a particularly appropriate topic for consideration before the American Association of Anatomists on this occasion. Others might suppose that since all of us are morphologists we are naturally familiar with this trend and such a discussion is out of place or useless. Yet are we as workers in a science always conscious of its trend, or is the trend the same in the minds of any number of us? It may be that each sees the trend from the view-point of his own endeavor and any one might have difficulty in convincing his colleagues that he is looking straight forward rather than sidewise or possibly even backwards. The exact direction of progress is somewhat problematical and attempting to follow it becomes an experimental venture, since the speaker is forced to employ his own personal compass and takes the chance of being alone or in a company of questionable size when the end of the survey is reached. In spite of the risks involved, I shall attempt to trace an impartial outline of the growth of morphology with an analysis of its sudden modifications at the beginning of this century and the possible effects of these on its immediate problems.

The very early history of the subject has no place in such an outline, and a convenient point for starting is with the introduction of the definite term *morphology.* It is strangely interesting that this word was first used by one of the most romantic poets of history, who at the same time chanced to be an eminent morphologist of the early nineteenth century. Goethe, in 1817, employed the word to indicate unity of structure in place of the more awkward term *metamorphosis* which had been applied in a similar sense by the great naturalist Linnaeus. Goethe's instinctive biological ideas frequently occur even in his poetry and drama—in the poet's great masterpiece Mephistopheles remarks to Faust the oft-quoted morphologic truth, "Blut ist ein ganz besonderer Saft!" All hematologists are still unwilling to disavow it.

The investigation of living mechanisms considered as the structural side of biology has followed in its history something of a parallelism with the two other great natural sciences—physics and chemistry.

[1] Address of the president of the American Association of Anatomists, University of Rochester, New York, March 27, 1929.

Throughout their early periods the three sciences were almost entirely concerned with the study of crude masses of stuff. It was not until near the beginning of the nineteenth century that rapid advance was made in approaching the true composition of physical matter and the arrangements of the finer parts in the living organism. The old phlogistic doctrine in chemistry was overthrown by Lavoisier only during the final quarter of the eighteenth century. And it was during the last century that matter displayed to the chemist much of the nature of its atoms and molecules through methods of accurate quantitative analysis and measurement, and that physics advanced so rapidly in its mastery of the energies of heat and electricity. Also during this period, and long after the invention of the microscope, living animal and plant bodies were seen to be composed of their organizational units, the cells, and many of the important intracellular elements were discovered and deeply considered by morphologists.

Again the parallelism persists in that near the beginning of the present century discoveries were made which completely revolutionized the future development of the three natural sciences! As Professor Millikan[2] has strikingly expressed it for physics:

> . . . in 1893 so sure were we of the physical foundations of our world . . . that it was then being frequently said, often by the ablest of physicists, that it was probable that all the great discoveries in physics had already been made and that future progress was likely to arise only by increasing the refinement of our measurements. Then came, only two years thereafter, the capital discovery of X-rays, an entirely new phenomenon, having no relation whatever to refinements of measurement. And two years later came radioactivity, which has now completely exploded the notion of the eternal character of the atom and revealed a world in which many if not all of the so-called elements are continually undergoing change. . . . And then three years later came the beginnings of the quantum theory, which has shown us unmistakably (so it appears) that in the domain in which electrons live even Newton's laws no longer hold.

By strange coincidence, at just about the same time the laws of heredity, discovered thirty-five years before by Mendel but completely unappreciated by the biological workers of that day, were rediscovered when the state of morphological knowledge was so exactly ripe for a general comprehension of these laws that a sudden impetus shot through the entire realm of biology, revitalizing its twentieth century progress.

These great discoveries near the close of the century have advanced the quest for the ultimate nature of structure to a study of the interior of the atom, electronic arrangement, and of the interior of the cell nucleus, the arrangement of the chromosome and the gene. Thus all qualitative differences have come closely down to an ultimate problem of arrangement! Had the exploitation craze of to-day sufficiently impressed this association we might proclaim—universal morphology!

Here general comparisons must finish and we proceed with the discussion of the limited subject with which we are more suitably qualified to deal.

In order to sufficiently evaluate the importance of the earlier contributions as a foundation for the twentieth century renaissance in morphology we may consider very briefly the morphological interests of the nineteenth century.

During the early part of the century a morphological foundation for a clear exposition of the theory of evolution was being carefully laid. The morphologists of that time fully recognized the relationships of organisms on the basis of their common structures, and they arranged animals and plants in accord with the various degrees of similarity which clearly divided them into more nearly and more distantly related groups. Homologous systems and organs were particularly recognized throughout the vertebrate kingdom, and slightly graded differences in these structures were found among closely similar and apparently related species. Many morphologists were definitely convinced that organic evolution had taken place and that this phenomenon accounted for these structural homologies.

Cuvier may be called the most conspicuous comparative anatomist of the early years of the century, although the philosophic side of anatomy did not strongly appeal to him. His influence and discussions, however, stimulated study which was carried on in France by a list of able anatomists—de Quatrefages, A. Milne-Edwards and Lacaze-Duthiers; in Germany by Bojanus, von Siebold, J. F. Meckel, Johannes Müller and others; while in England Sir Richard Owen was the leading exponent of this school.

Somewhat contrasted with these investigators and probably, from a modern standpoint, in advance of them was a more transcendental or philosophic school clearly led by Geoffroy St. Hilaire and conspicuously supported by Goethe and Oken. St. Hilaire's brilliant contributions, "Philosophie Anatomique," 1818–1823, present an array of surprisingly analytical deductions among which are contained fundamental conceptions of structure and important doctrines of development. The unity of organic composition and evolution were appreciated in complete harmony with the ideas shortly before advocated by Goethe. The theory of analogies emphasized the fact that the same parts differing in structural degree occur in all ani-

[2] "The Practical Value of Pure Science," SCIENCE, 59: 9. January, 1924.

nals. Yet the most remarkable conception was St. Hilaire's "principe du balancement des organs" upon which he founded the study of abnormal development r teratology, and claimed in a clearly modern sense hat the high development of one organ is associated ith a suppression or a diminution in the development f another. This conception anticipated by almost wo generations Roux's ideas of "der Kampf der Teile," or the struggle of the parts in the developng organism. Some of the most recent findings in xperimental embryology add convincing demonstraion of the truth of the "principe du balancement des rgans" as expounded more than a century ago. The dea is, therefore, old, but the experimental proof of ts truth is so recent that some are at times inclined o feel that in demonstrating the fact they actually riginate the idea—but not so. Long ago was visioned

The nations' airy navies grappling in the central blue,

ut the actual demonstration was painfully recent. he demonstration, after all, is the vital thing in ience.

Any one viewing the history of biology during the arly part of the past century will be impressed by he paramount rôle which morphology played in ringing the human mind to realize that organic volution had taken place. In fact, it is difficult to onceive how from any other than the morphologic tandpoint evolution could have been comprehended. his is recognized without any intention of reflecting n the physiological phase of the problem. It is perectly fair to point out the peculiar prominence of ne division of biological study in any particular onception. Morphology and physiology are not ompetitive or antagonistic fields or points of view, ut structure and function are indelibly correlated nd mutually dependent parts of one whole, if not ctually the same thing! The function of an automobile depends not only upon the structure of its arts but their arrangement as well, and no one will eny that the functioning of the machine alters its ructures until their arrangement ceases to be an utomobile. The performance of a mechanism reacts n its structure so that the modified structure gives ew function and the two phases therefore move ogether.

The vast sum of knowledge accumulated by comarative morphology before the latter quarter of the ineteenth century had largely been amassed on the imple basis of descriptive observation. There had een scarcely an intimation of effort to analyze exerimentally or test the meaning of structures. orphological descriptions had become more and ore exact and minute in their detail, and morphometry had been developed to a considerable degree. Histology had been founded by Koelliker and cellular pathology by Virchow, whose aphorism *omnis cellula e cellula* was vigorously advocated as a fundamental law. At this stage, during the last quarter of the century, a most fortunate innovation occurred for the science of morphology with the introduction of the experimental method. The movement originated and first developed in Germany, but was soon introduced into the biological laboratories of this country. The names of Roux, Oscar and Richard Hertwig, Driesch, Boveri and others are among the pioneers in this method of attack which many would claim actually started morphology on a strictly scientific basis.

It must at once be recognized that we are referring to the introduction of the experimental method particularly into morphology and embryology rather than into the broad subject of biology. No one forgets that many of Darwin's painstaking and long-carried-out studies were partly experimental, and he, of course, always displayed a penetrating appreciation of nature's own experiments as well as of that great experiment to which so many forms, including man himself, have been subjected—domestication. Other accidental and more or less disconnected experiments are recorded in the history of biology for centuries back, but a systematic experimental morphology and the analytical study of the development and formation of structures was actually begun by Wilhelm Roux, the anatomist of Halle, as truly as by any one person. And this experimental attack was quickly adopted by many of his countrymen and, next in order, by American workers. There were early studies of polarity, of the predetermination of the embryonic axis, of germinal localization or promorphology in the unfertilized egg through efforts to fragment the egg, of potencies in the segmenting egg through the separation of blastomeres, the destruction of certain regions of the egg, the inversion of the egg and many other more or less mechanical performances.

These early experimental studies brought the problem of morphology closely down to the potentialities of the embryonic cells as the units of structure and revived on a modern basis what one may call the "cell theory." Certain things were appreciated, however, such as multinuclear cells—syncytia, etc., which caused some investigators to question the validity or the universality at least of the cell doctrine.

Looking back on these discussions of the inadequacy of the cell theory we realize that from our present standpoint the actual boundaries of the cell and other contra arguments are not necessarily of great import, and from a pragmatic point of view biological reason-

ing is greatly facilitated by an appreciation of the cell not as an ultimate simple unit but as the ultimate biological organization.

One of the most fascinating and fundamental chapters in morphology is that concerted study of the nuclear structures of the cell during the last two decades of the nineteenth century. We must here give attention to the significance of some of these studies, since through them the foundation was laid both for an analysis of the phenomenon of inheritance and an understanding of the structural behavior within the cell. The controversial cell theory becomes lost in the vigorous consideration of the individuality of the chromosomes within the nucleus. These bodies and something of their behavior during cellular reproduction had for some time been known before they were christened in 1888 by the eminent anatomist Waldeyer as "chromosomes." Five years earlier W. Roux in his study "Über die Bedeutung der Kernteilungsfiguren" had supposed that the formation of the chromosomes from long threads brought about an alignment in linear series of different materials or "qualities"! Then by longitudinal splitting of the chromosomes as an early step in nuclear division all the "qualities" are equally divided and passed to the two daughter nuclei. This interpretation by Roux is astounding in minute accuracy of conception, and actually in the light of our knowledge to-day it is equally as remarkable as Weismann's prediction of a reduction of the chromosome number during the maturation divisions.

It had become recognized through many studies that the chromosome number was constant for a given species, and Weismann in 1887 predicted on theoretical grounds that in order that the number might remain constant through generations there must be a place somewhere during the maturation of the germ cells at which the chromosome number is reduced to half and in bisexual reproduction the original number is again restored at fertilization by the union of the egg and sperm. Boveri in 1888 advanced a somewhat similar conception. The actual phenomenon of reduction was first observed three years later by Henking for the insect Pyrrhocoris, soon after for other forms by Häcker, vom Rath and others, but in particularly satisfactory detail by Rückert in 1894 for the copepod, Cyclops.

These studies of the reduction division gave emphasis to the importance of the rôle of the chromosomes and strengthened the idea of their individuality as cellular structures. The modern theory of the individuality of the chromosomes had already been promulgated in 1885 by the anatomist Karl Rabl. However, we recognize this theory as having been successfully championed by Boveri with a series of splendid studies extending through almost his entire scientific life.

The idea of the individuality of the chromosomes was actively opposed on the basis of the occurrence of amitosis before this method of division had been very fully understood. Science advances through a struggle with opposition—but it remains an open question whether the oppositionists actually aid in the advance. Much effort is often wasted in vain attempts to convince contrary minds of the actual direction from which the light comes.

We may now say that during the past thirty years such a formidable array of evidence has accumulated in support of chromosomal individuality that no reputable cytologist longer fails to accept it. Not only is this true but the individuality of the chromosome has been further advanced to the "theory of the gene." And this theory has rapidly gained through the experimental analysis of linkage, crossing-over, non-disjunction and other morphological conditions through which the loci for many of the genes are now mapped in series along the chromosomes, in one animal form at least.

Much of the advance in our knowledge of finer morphological arrangements was contributed by anatomists of the European medical faculties—Flemming, O. Hertwig, Rabl, Roux, Rückert and many more, but in this country until very recently such studies have been confined almost entirely to the zoological laboratories of the universities—and this is somewhat of a reflection on our anatomical situation.

Just when the knowledge of cellular morphology had reached so advanced a position an apparently unrelated event occurred in biology—the rediscovery of Mendel's laws of heredity. One is justified in referring to this event as apparently unrelated to cellular morphology, since Bateson, himself one of the rediscoverers of Mendel's laws, was never quite able to fully appreciate the morphological background in analyzing heredity. These laws, which involve a sorting out or segregation of characters during inheritance, were, nevertheless, quickly linked with the behavior of the chromosomes in the maturation of the germ-cells and the fertilization of the egg.

The germ-cells, as we know, have when immature the diploid or double set of chromosomes, but in passing through the transformation into either spermatozoon or egg the chromosomes arrange themselves in pairs, and then a peculiar type of division takes place in which the chromosomes do not split as in ordinary cases but the members of each of the chromosomal pairs separate and a single chromosome goes into one of the daughter cells and its mate goes into the other. In the chromosomal pairs one member is derived originally from the mother and the

other from the father, as Montgomery first suggested in 1901. He further emphasized the peculiar fact that although this side-by-side pairing of the chromosomes, synapsis, in the maturation of the germ-cells actually comes at the very end of development it is, nevertheless, the final and most minutely accurate step in fertilization. Each mature germ-cell receives only one or the other, either the paternal or the maternal, member of every chromosomal pair, and the total chromosome number in each cell is thus reduced to half. The behavior of the chromosomes, therefore, exactly parallels the behavior of the Mendelian characters since each unit derived from the father separates from the corresponding unit derived from the mother. The two factors of a pair are allelomorphs of each other. Their separation in the germ-cell is morphological segregation and on it depends the segregation of characters in the development of the offspring.

The first clear explanation of Mendelian phenomena on the basis of the behavior of the chromosomes was presented by a young student of zoology, W. S. Sutton, in 1902. Sutton recognized in the group of heteromorphic chromosomes of the grasshopper that each of these individual chromosomes was probably a qualitatively distinct thing carrying certain hereditary characters. He further thought that one chromosome might carry a number of characters. And he then pointed out the similarity between the processes of segregation in the reduction of the chromosomes and the inheritance of characters, and went further to explain that the chromosomal pairs segregate independently of one another just as two characters in Mendelian heredity may be transmitted independently. Two such characters were thus determined by factors located in different chromosomes. On the other hand all the factors carried by the same chromosome should tend to remain together, and the number of characters may be many times larger than the number of chromosomes. These ideas are now somewhat crude since we no longer have unit characters related to only a single factor, nevertheless, they were brilliantly conceived.

Very soon after Sutton's analysis, Bateson and Punnett in 1906 discovered the linkage of characters in inheritance but did not give a chromosomal explanation; however, Lock almost immediately called attention to the possible relation between linkage and the chromosomal hypothesis. Morgan and his associates have since discovered and arranged in a most definite way the four great groups of linked characters in Drosophila corresponding with the four chromosome-pairs in this animal.

During synapsis, the homologous chromosomes pair in such a manner that any factor or gene in one chromosome lies opposite the comparable factor or gene, its allelomorph, in the mate chromosome. In certain cases, Morgan, Sturtevant and Bridges have supposed that genes from one chromosome may cross-over or swap places with the comparable genes in the other chromosome of a pair, since certain characters in heredity actually cross-over, forming new linkage groups, as is shown by the expression of characters in the finished individual. Again there are cases in which the two chromosomes of a pair in synapsis fail to separate, and remaining together the entire pair passes into one of the mature gametes. This behavior during the reduction division is termed non-disjunction. When such a cell is fertilized a zygote is produced which carries an extra or additional chromosome and, correspondingly, it develops a confused complex of characters. This condition splendidly illustrates the influence of genetic constitution on ontogenetic development.

Through a systematic study of linkage and crossing-over, it has been possible to estimate the probable frequencies of crossing-over or the rearrangement of linkage groups. It is logically supposed that the closer together two genes lie in the linear arrangement of genes in the chromosome the less likely are they to be separated, and the further apart the more likely, when crossing-over does occur, and on the basis of cross-over frequency the loci of the genes in the linear chromosome have been carefully determined and the reliability of this map is constantly tested experimentally by the behavior of the characters in inheritance.

This modern study of genetics closely associated with a study of the physical structure of the cell and particularly with the chromosomal reactions has contributed a most astounding picture of ultimate morphology, and the story of the gene as presented by Morgan and his associates is comparable only to the quest of the atom and the electron.

In spite of the accuracy in location of the genes one must not form too simple an idea of the behavior of factors in inheritance. The complexity of the situation is due to the fact that many factors may affect the same character. As Morgan pointed out some years ago, "Red eye color in Drosophila, for example, must be due to a large number of factors, for as many as twenty-five mutations for eye color at different loci have already come to light." And further, "the factorial hypothesis disclaims any intention of making one unit character the sole product of one factor of the germ." In speaking of factors for eyes or for legs one must really mean differences in factor balance that produce effects only in the eye, the leg or other regions of the body.

We as anatomists should feel a peculiar satisfaction in that all these so beautifully delicate phenomena have been analyzed on a strictly morphological arrangement.

Morphology, then, has not only formed the fundamental basis for the establishment of the evolution and common relationship conceptions, but again cellular morphology lays the foundation on which modern genetics was begun and so brilliantly developed in this country. These facts must be appreciated in order to properly estimate the field in which we labor; yet not all morphologists fully realize their opportunities and responsibilities in these directions.

The changes thought of in association with embryonic development must now be considered in view of the necessity of relating these processes to the rôle of the genetic factors. To bring up our thread of the embryological side of morphology we find that the early mechanical experiments had before the end of the nineteenth century been supplemented by other experiments in which modifications in the chemical and physical environment of the embryo were employed.

The first experiments on modifications in the chemical environment seemed to give rise to particular types of structural defects as reactions to specific chemical treatments and, following the lead of Herbst with his "lithium embryo" of the sea urchin, it was a common fault to interpret these developmental reactions as specific responses to the chemical agent employed. The so-called lithium larva, for example, was later produced in several species of animal eggs. This larva showed a very peculiar deformity which was unknown in nature.

However, in treating vertebrate eggs with certain chemical substances, the speaker found in 1907 that well-known typical deformities could be consistently produced. This had important significance in advancing an understanding of structural anomalies and their origin. But in attempting to interpret the cause of a particular deformity the mistake was at first made of classing it as a specific response to the treatment used. During the following year, however, in experimenting with a number of different chemical substances or modifications of the environment I found that all these would produce the one definite developmental defect provided the eggs were treated during the same developmental stage. It was then realized, and recorded in 1909, that the defect was due to an anesthetic or slowing effect on the rate of development, and the following year it was shown with fuller results that the type of deformity was associated with the developmental stage of the egg at the time of the experimental treatment rather than with the specific nature of the treatment used. These results, in a way, though not until later appreciated, accounted for the constant repetition of the same type defect in the earlier experiments of Herbst and others with lithium compounds. The same defect had repeatedly occurred simply on account of the fact that the investigators had constantly subjected the eggs to the chemical substances during similar developmental periods.

On further expanding this line of investigation during the following ten years it was found that a great many different typical defects which occur in nature could be produced by any one method of experimental treatment—for example, low temperature, provided the eggs were subjected to the treatment during different developmental stages. On the other hand it was repeatedly shown that a great variety of treatments may produce only one and the same defect if the eggs be subjected to these treatments at the same developmental period, as was first recorded for a number of anesthetic substances in inducing the eye defects of Fundulus in 1909 and 1910. As stated then:

> Eye defects, in fish embryos at least, are produced by lessening the developmental energy at certain critical stages. This is readily accomplished by treating the developing embryo with anesthetics.[3]

These facts made it certain that the action of the chemical substance itself was not specific in modifying vertebrate development, and this was rapidly and further confirmed by McClendon and a number of other workers on a variety of embryos. Thus it is the embryonic stage at which the treatment is applied which determines the type of response and not the nature of the treatment.

There are critical and passive moments in the development of the embryonic organs which are associated with the fact that a certain part or organ is in an active or rapid state of development at a given time while at other times this part may be developing more slowly or possibly be in a state of rest, and at such a time the given part is not readily affected by modifications in the environment. The critical stage is the time at which the particular organ is developing at its highest rate and probably at a rate higher than any other point in the embryo at this exact period. The experimental treatment when effective causes the embryo to react by slowing or lowering its general rate of development and the most rapidly active part is most affected; in other words, the treatment acts very much as an anesthetic would, and lack of oxygen and low temperatures, as Loeb, Kellicott and many others have found, slow the developmental activities in the same way. Thus, generally speaking, most defects are the result of developmental arrests

[3] Stockard, *Proc. Soc. Exp. Biol. and Med.*, 7: 2. 1909.

Dareste believed, without wide experimental evidence, as long ago as 1891.

When a particular organ is once arrested or slowed in its development it is subsequently unable to overcome this handicap on account of the fact that some other organ has now reached a point in its development or ripeness when its high rate of activity enables it to dominate the situation, and this new organ itself may then tend to inhibit the development of other organs. The idea of such competitive actions among the developing organs has long been discussed in both animals and plants.

Any occurrence which tends to cause an abnormally slow rate of development will almost invariably produce an anomalous structural condition. Newman in 1917 showed in a most striking way that hybrid fish embryos actually exhibit the same types of abnormalities that are obtained by other experimental procedures, and he clearly interpreted these as being of the nature of developmental arrests, or in other words, the result of the slow hybrid development.

Changes in rate of development and different rates of cell multiplication may be clearly observed and appreciated, and it seems certain that these changes determine the type of structural reaction. The natural causes of the changes in the rate we do not know. But making tests to demonstrate that a rapidly growing part is metabolizing rapidly or oxidizing rapidly is about comparable to finding that an engine running at high speed is burning more fuel in a given time than one going slowly. We have long known that speed costs something and fast living is reputed to be somewhat more expensive than slow.

All the explanations regarding the relation of one developing organ to another actually in a sense go back a hundred years to the old ideas of Geoffroy St. Hilaire in his "balancement des organs," as well as more recently to Wilhelm Roux's "Kampf der Teile."

Not only does an inhibition of developmental rate induce abnormal expression in an organ of the single embryo, but almost ten years ago I found experimentally that an arrest during very early stages of development may actually cause more than one embryonic body to arise on the germ-ring, and thus twins or multiple vertebrate embryos may be produced. In these double embryos the competition between the two components is strikingly shown, the superior development of the one will constantly tend to inhibit the other.

It further seems very probable that this occurrence of twinning is more readily induced in one species of embryo than in another, in other words, there is a constitutional or genetic background affecting the readiness of this reaction—for example, among fish the trout embryo tends to double or form twins much more easily than do the embryos of the minnow, Fundulus, while on the other hand possibly Fundulus tends more readily than the trout to give the cyclopian defect.

Most important analogies to these phenomena have arisen in the genetic studies of the expression of certain mutations in modified environments. Miss M. A. Hoge in 1915 found an important influence of low temperature on the expression of a Mendelian character. When a definite mutant line of Drosophila was kept at low temperature, accessory and double legs were inherited in an exact Mendelian ratio. In the double legs one component tended to be a mirror image of the other, thus a typical twin extremity. However, when this line of flies was bred at normal temperatures the double legs did not occur in the Mendelian ratio. The slow development at low temperature was necessary in order to obtain the full expression of this genetic character! Of course the ordinary lines of Drosophila lacking this mutant character do not develop accessory legs in these low temperatures. Morgan recorded a similar behavior in the inheritance of abnormal abdomen in flies as associated in expression with a humid environment.

These environmental influences on the development or expression of a character in an individual emphasize the important fact that the absence of a character in a person does not at all mean the absence of the necessary factors from the germ. There is the double problem of transmission and expression; a character may be inherited but on account of unfavorable developmental conditions it does not develop or may be suppressed. The child may inherit the mouth shape of its parents and yet may exhibit hare-lip and cleft palate. As Morgan again remarks,

> In cases where, on the factorial hypothesis, a certain factor is expected to be present in an individual, then, even if the individual fails to develop the character commonly taken as indicative of the factor, the actual presence of the factor may be demonstrated by breeding tests.

If circumstances are provided like those in which the character previously appeared it will show itself again. With a race of guinea-pigs I have found this to be true even for the five-toed character which has probably been unexpressed for hundreds of years or generations since all wild guinea-pigs express only four front and three hind toes.

The studies on the modification of the developing embryo and its rather definite responses led to attempts to modify the germ cells of parent generations with the idea that such changes might be recognized by altered growth and development in the progeny

and by possible transmission. My own experiments along these lines were conducted through a number of years on a great many individuals, but unhappily the treatments used failed to produce localized or limited modification in either the germ cells or the subsequent offspring. The more severe treatments did, however, produce a generalized injury to both male and female germ cells and caused very definite discrepancies between the histories of the experimental generations and the control animals. All these deficiencies in development were such as would be expected to result from general injury to the germ cell rather than from a limited or specific modification. Other workers have been more successful and, in particular Little and Bagg, by treating mice with X-rays seem to have produced a strain of animals which consistently transmit developmental abnormalities.

Here again the type of abnormality is more in the nature of what one might expect to result from a general injury to germ plasm rather than to a specific modification of any exact or definite nuclear part. However, the abnormalities, such as defective kidneys and deformed feet, seem to be definitely transmitted through a number of generations.

Finally, with X-ray experiments, Mavor, and still more accurately Muller, have succeeded in actually affecting certain definite factors or, morphologically speaking, genes in the germ cells of the fruit fly, Drosophila. In Muller's experiment in particular it seems clearly shown that the X-ray has actually caused changes in certain genes giving rise to mutant conditions that are inherited in definite Mendelian ratios. Even here the new characters resulting from these modifications might all be thought of as defects or deficiency responses in spite of their accurate inheritance. However this may be, it is highly important and stimulating to find that hereditary factors themselves may be subjected to experimental modification and analysis. This becomes an attack on the most minute morphologic unit of which we have ever conceived.

While many of the foregoing conceptions were being developed physiologists as well as morphologists were recognizing the fact that certain peculiar substances, hormones, produced within the organism were capable of modifying its morphological characters and actually, in many ways, directing the structural end pattern. Lillie's enlightening studies of the freemartin calf showed how during early intrauterine development the hormones produced in one fetus may completely alter the normal structural development of his sister twin. This study also impresses us with the importance of the very early production of a specific organ hormone and its rôle in directing structural response. The classical embryological experiments with the thyroid now so extensively confirm leave no doubt of the necessity of the thyroid hormo as a stimulant for structural metamorphosis an development.

The chemical nature of the individual hormo produced by a given gland, such as that from th thyroid, seems to be closely the same throughout th vertebrate kingdom, but the action of this comm stuff in each vertebrate species plays upon a differe constitutional complex of genetic factors and brin about a varying series of specific reactions.

In the embryonic body Spemann has recently reco nized the existence of what he terms "organizer closely suggestive of hormones. Such substances se to act on the embryonic cells or groups of cells i such a way as to harmonize development and bri about an orderly expression of the systems of th embryo. One of the striking results from the valuab experimental work which has been done on the rô of these "organizers" is the demonstration that wh a group of cells taken from a certain region of th body of the embryo of one species is planted in different part of an embryo of another species, th group of cells is induced to develop into the en organ which should occur in the position at which was planted, but in spite of this it is also found th the foreign tissues nevertheless retain the speci characteristics of the embryo from which they we originally taken. Although the "organizers" have th power to cause embryonic cells to form an org proper for the place, the same "organizers" are qui unable to modify the factorial complex which giv to these cells the characteristics of their mothe species.

Such results are closely in harmony with the ver clearly expressed idea of Morgan, that "differentiati is due to the cumulative effect of regional differen in the egg and embryo, reacting with a compl factorial background that is *the same in every ce* Thus the regional differences have something ass ciated with them which brings about differentiatio without actually modifying the complex factori background of the cells. It is certain that since ever cell of the body has the same factorial or genetic com plex, these factors can not cause differential reactio in development. But it is equally certain that durin early cleavage the different cells very soon lie in su positions that almost all of them experience sligh differences in environmental contacts—some cells li almost entirely at the surface and others almos entirely within the blastula; these slight environment differences acting on the common genetic complex ma cause the production within the various cells of dif ferent chemical substances and these would give dif ferent growth reactions which steadily increase the

fferences as development progresses. These reac-
ns bring about the changing internal environments
hich have originally resulted from the outer envi-
nmental contacts. When outer environments are
ered, differentiation should be altered and this is
e as is demonstrated by anomalous developments in
dified surroundings.

Our present view is a considerable advance over
old proposition of Driesch, which, however, was
rtly correct, that the development of a cell is a
nction of its position. Driesch of course at that
e knew very little of the exact genetic constitution
the cell and the interplay between this and the
vironment.

The old efforts to analyze promorphology and the
culiar differences in the reaction of blastomeres
om the embryos of various species made it impos-
le to fully reconcile all the apparent developmental
ntradictions which arose, and finally, as Jennings
ently deplores, this caused Driesch to despair of
experimental solution and to fall into the pit of
taphysical speculation. But as Jennings[4] goes on
say:

> We find that we can not naively transfer the results
d principles that we obtain by experimenting on one
ganism to another organism; or even to another part
the same organism. We find that what one organism
n't do, another can. We find that what a given or-
nism doesn't usually do, it may do when put to it.

In view of these difficulties, morphology has reached
stage where its problems must be considered only
the light of the hereditary constitution of the
ganism and the reactions that this may give during
various stages of development with the changing
ternal and external environments. The modifica-
ns of these reactions during all the developmental
riods from fertilization to manhood must be studied
d analyzed in order that the actual differences
tween a normal man and an acromegalic giant may
expressed with an approach to scientific accuracy.

Perhaps the experimental studies of the chemical
d physical environment as affecting the embryo
ould aid in preparing the way for a final conception
the action of hormones and internal chemical dis-
rbances on postnatal growth and development. The
etamorphosis of puberty and the functional changes
sociated with it, youthful growth and senility itself
e all morphological reactions to environmental
ange. And actually the vitamins—that strange
oup of substances probably related to the hormones
t supplied by the outer environments—are also
und to be intimately concerned in influencing struc-
ral reactions during development. The splendid
work of Evans along these lines has not only given us valuable knowledge of the influences of vitamins on the early processes of reproduction but has also afforded through morphological response the recognition of a new vitamin.

Before this point some of you may feel that I have widened the discussion of morphology entirely across the field of general biology, but on second thought I trust that it will be admitted as true that any investigation involving the development, growth or modification of living structure is a problem in morphology, and all methods, chemical, physical and physiological, applicable to an analysis of structural reactions are the tools of the morphologist.

In conclusion, I should like to recall a statement made to me years ago by a most eminent anatomist. I was undertaking the organization of an anatomical laboratory and he remarked, "You will find gross human anatomy to be scientifically bankrupt." It seems to me now that only a brief scientific stock-taking is necessary to show how richly solvent rather than insolvent this subject actually is! Gross anatomy is not bankrupt; it is simply not understood! A real understanding of gross human form and structure necessitates an accurate knowledge of the processes of heredity, a clear conception of the many phenomena which have occurred during embryonic development, a knowledge of postnatal growth and differentiation along with an appreciation of the many internal and external influences which may modify the developmental course during its various periods. An approach to such an understanding will be deeply essential for a truly scientific conception of the differences among human constitutions. From this point of view it would seem improbable that any one other than a thoroughly grounded morphologist could possibly be capable of giving a complete diagnosis of an adult constitution. With a different vantage point one might still recognize some of the more evident constitutional differences—the high spots—but an actual analysis of the important finer variations in constitution, almost all of which give typical structural symptoms, is left alone for the future anatomist!

There is even a relevant problem as to whether certain immunities of manhood as contrasted with childhood susceptibilities do result from mild infections rather than from developmental changes. The adult is not the same animal as the child—it has many additional structures and secretions and its failure to contract diseases of childhood that it has never exhibited may not in all cases be due to an acquired immunity resulting from long mild exposure so much as to a sort of species immunity, since the two ages are two different animals. There is probably in

[4] SCIENCE, 64: 99. 1926.

many ways a wider discrepancy in organic structure and internal environment between a senile man and a new-born baby than between an old man and an old gorilla!

Human anatomy on this basis is the outstanding morphological problem. Only the old "surgical handmaid," let us thank Providence, is bankrupt, and this fact is the actual redemption of anatomy in this country.

The trend of morphology is passing beyond the descriptive phase with its refinements of measurement and towards a comprehensive analysis of the causes underlying structural reactions.

And, as morphologists, we are fortunately able to sit-in along with the geneticist while Nature shuffles and deals the chromosomes which carry the fortunes of life to her sons and daughters. To one the cards may be stacked for all that is rich and good, while to another may be dealt deformity and disease; yet all must play these hands in the vital game of somatic development and gametic transmission.

C. R. Stockard
Cornell University Medical College,
New York, N. Y.

SCIENTIFIC EVENTS

THE NATIONAL PARK SYSTEM

A statement in regard to national parks has been made public by the Department of the Interior according to which an area of approximately three square miles of spectacular scenic beauty has just been added to the Acadia National Park, on the coast of Maine, through the acceptance by the secretary of the interior of deed covering this land. The newly added section is on Schoodic Peninsula, a bold point across Frenchman's Bay on the opposite mainland from Mount Desert Island, where the main portion of the park is located.

Authority to accept gifts of land on the neighboring mainland and to change the name of the park from Lafayette to Acadia was contained in the Act of Congress approved on January 19 of this year. The entire area of the park, now totaling fifteen square miles, has been donated to the U. S. government by prominent easterners headed by George B. Dorr, of Boston and Bar Harbor, the present park superintendent.

The largest single addition to the park system during the year was caused by the creation of the Grand Teton National Park, Wyoming, by act approved by President Coolidge on February 26, last. This park, with an area of 150 square miles, includes the famous Teton Mountains, a magnificent range that has been under consideration for a number of years for addition to the Yellowstone National Park.

The Yellowstone itself was increased by the addition of seventy-eight square miles on its north and east boundaries, to take in the headwaters of the Lamar River. No roads, hotels or camps will be constructed in this new section of the park.

Lassen Volcanic National Park, in northern California, was enlarged by the addition of thirty-nine square miles of interesting volcanic territory through congressional enactment. Further legislation gave authority to consolidate or acquire alienated lands within the exterior boundaries of the park.

Bryce Canyon National Park, in southern Utah, was established on September 15, 1928, under authority previously granted by Congress. Its area is twenty-two square miles. The main feature of this park is a great amphitheater filled with innumerable fantastically eroded pinnacles of vivid coloring.

Other congressional legislation of national park interest included the enactment of a law accepting the cession by the state of Colorado of exclusive jurisdiction over the lands embraced within the Rocky Mountain National Park. The passage of the state act ceding jurisdiction ended a controversy of several years' standing between the federal and state governments.

Authority was granted for the establishment of a Bad Lands National Monument in the State of South Dakota when and if the lands necessary for inclusion are donated to the federal government.

The president of the United States was authorized to appoint a commission to study further adjustments in the boundaries of Yellowstone National Park, with special reference to the Bechler River Basin.

Authorization was also granted the secretary of the interior to investigate and report to congress on the advisability and practicability of establishing a national park to be known as the Tropic Everglades National Park in the state of Florida. The area under consideration will be inspected by government park experts next fall.

Especially important was the passage of the annual appropriation act, carrying appropriations or authorizations for expenditure for national park purposes of about $12,000,000.

APPROPRIATIONS FOR THE RESEARCH WORK OF THE DEPARTMENT OF AGRICULTURE

In the 1930 appropriation act congress has continued the policy of expanding and strengthening the work of scientific research so as to enable the department to render greater service in this respect to farmers in every section of the country. Last year congress increased the funds for research by items totaling $1,800,000 for the work of the department

[...]d $480,000 additional as payments to the states [...]der the Purnell act for the state experiment sta[...]ns. These increases brought the estimated expen[...]ures this year for research in the department up to [...]proximately $13,000,000, and the payments to the [...]tes for research to $3,840,000. In the 1930 act [...]out $1,500,000 additional is provided for research [...]the department and $495,000 for the state experi[...]nt stations and the Hawaii station.

[...]Among the larger increases for research are a new [...]m of $160,000 for investigations by the department [...]the causes and means of prevention of destructive [...]l erosion and the conservation of rainfall by ter[...]ing and other means; $300,000 for intensive ento[...]logical and plant-breeding work to meet the serious [...]ation arising out of the prevalence of leaf-hoppers [...]d resultant curly-top disease of sugar beets and [...]er important truck crops; $160,000 for forestry [...]earch projects (principally for items under the [...]Nary-McSweeney Forestry Research act); $80,000 [...] investigational work in the Bureau of Animal [...]dustry, including $38,000 for studying contagious [...]ortion of cattle; $97,000 for the research projects [...]the Bureau of Dairy Industry; $325,000 for in[...]stigations of the Bureau of Plant Industry, and [...]5,000 additional for eradication work under that [...]reau on the phony disease of the peach in the [...]uth; $100,000 for projects of the Bureau of Chem[...]ry and Soils, exclusive of the $160,000 erosion item [...]eviously listed, which is to be handled by the Bu[...]u of Chemistry and Soils and several other bu[...]us; $168,000 for insect research by the Bureau [...]Entomology, including $40,000 additional for corn[...]rer research; $45,000 for the investigational work [...]the Bureau of Agricultural Economics; $27,000 for [...]ricultural engineering research projects under the [...]reau of Public Roads; $20,000 for investigations [...]the Bureau of Home Economics, and an increase [...]$60,000 for the special research program which the [...]partment is conducting to find ways and means [...]meet the situation in farming arising out of the [...]festation in this country of the European corn-borer. [...]is makes a total fund of $210,000 for 1930 for the [...]ecial corn-borer program, which involves work along [...]gineering, cultural, economic and other lines as [...]stinguished from the research and control work [...]ating to the corn-borer itself as an insect. There [...]also an increase of $100,000 in the appropriation [...]r printing for the department, which at present is [...]dly congested.

[...]HE AMERICAN MUSEUM OF NATURAL HISTORY

[...]The New York City Board of Estimate in Commit[...]e of the Whole has made appropriations aggregating $2,400,000 for the extension and development of the American Museum of Natural History.

Of this sum $750,000 was voted to match a like sum which had been given by Harry Payne Whitney for the construction and equipment of the new wing to be known as South Oceanic Hall. Mr. Whitney made his gift contingent upon the city providing an equal amount for the same purpose. The city's appropriation was provided for in the corporate stock and tax notes calendar and the $750,000 will be raised by the sale of serial bonds of the city.

George H. Sherwood, director of the museum, appeared before the board after Dr. Henry Fairfield Osborn, its president, had conferred on the subject with Mayor Walker and other members of the Board of Estimate. Mr. Sherwood confirmed the mayor's statement that the state already had appropriated $1,250,000 for the new addition to the museum building to be known as the Roosevelt Memorial, in honor of President Roosevelt, and the mayor declared that the city would match that sum with an appropriation of $1,650,000, of which $1,250,000, matching the state's appropriation for the Roosevelt Memorial, might be devoted to the construction of the foundation and the first two stories of the proposed wing to be known as African Hall.

The city's remaining allotment of $400,000 will be used for construction of a power house and heating plant for the African Hall and the Roosevelt Memorial, which have been so planned that both may be served from one plant.

Dr. Osborn told the mayor that the ultimate cost of African Hall would be about $3,050,000 and that, in addition to the Whitney gift of $750,000 for South Oceanic Hall, additional gifts of $866,000 from private citizens for the general use of the museum had been received.

Mayor Walker stated that, following its present policy, the city administration would stand ready to match with like sums all private subscriptions for the enlargement of the museum.

The American Museum of Natural History is governed by a self-perpetuating board of thirty trustees, of which the mayor, the controller and the president of the Park Board are *ex officio* members. The president of the board of trustees is Dr. Osborn; the first vice-president, George F. Baker, and the second vice-president, J. P. Morgan.

THE MILTON AWARDS FOR RESEARCH AT HARVARD UNIVERSITY

FORTY-ONE awards, amounting to more than $58,000, have been made to professors in Harvard University to enable them to carry on research during 1929–1930, under the provisions of the Milton Fund. A committee was appointed, consisting of Dr. Frank B.

Jewett, vice-president of the American Telephone and Telegraph Company, *chairman;* Professor Edwin F. Gay, of the economics department, and Dr. W. J. V. Osterhout, member of the Rockefeller Institute for Medical Research, to advise the president and fellows of Harvard College in making a selection among the investigations proposed by any member of the instructing, scientific or administrative staff of the university. The following have received grants for scientific research:

Irving W. Bailey, professor of plant anatomy, to study the cytology of living cambium and differentiated tissues.

Gregory P. Baxter, Theodore William Richards professor of chemistry, for two years, to enable him to continue a study of the temperature of the ice-point on the absolute scale.

Raoul Blanchard, professor of geography, to make in Eastern Canada a geographical inquiry from a human and economic point of view.

Percy W. Bridgman, Hollis professor of mathematics and natural philosophy, to enable him to continue investigations on the properties of matter under high pressure.

Emory L. Chaffee, professor of physics, and Theodore Lyman, director of the Jefferson Physical Laboratory, for an investigation of light sources and apparatus for isolating portions of the spectrum.

Lemuel R. Cleveland, assistant professor of protozoology, to permit him to study the relation of protozoa *in vivo* and *in vitro* to bacteria, and the life cycles of amebae.

William J. Crozier, professor of general physiology, for a study of the nature of central nervous processes.

Chester L. Dawes, assistant professor of electrical engineering, for a study of the electrical characteristics of ionized gas films.

William Duane, professor of biophysics, to continue researches on the physical properties of radiation, and on certain physical characteristics of living tissues.

Edward M. East, professor of genetics, for genetic researches on the genera *Nicotiana* and *Fragaria.*

Merritt L. Fernald, Fisher professor of natural history, to be used in connection with the further investigation of the relic floras of Newfoundland.

Norris F. Hall, instructor in chemistry, to be used to secure the services of an assistant and to pay for supplies to investigate the nature of acidity.

Leigh Hoadley, assistant professor of zoology, to study the early ontogenetic phenomena associated with embryonic segregation with special reference to vertebrates.

Grinnell Jones, associate professor of chemistry, to continue his investigation of the properties of solutions, inasmuch as moving his laboratory and technical difficulties have interfered with the original schedule.

Edwin C. Kemble, associate professor of physics, and Franzo H. Crawford, instructor in physics, to be spent for apparatus to continue the study of molecular spectra and the Zeeman effect in gases.

Alexander McAdie, director of the Blue Hill Observatory, to permit him to study the physics of the air, especially the thermodynamics of water vapor, and the quick determination of heights of cloud bases to enable aviators to get the speed of wind.

Noel Ewart Odell, lecturer on geology, to permit him to study dynamic metamorphism in Scotland and Scandinavia preliminary to a research on static metamorphism in mountain regions in the Canadian Rocky Mountains.

George H. Parker, director of the zoological laboratory, to permit him to spend six weeks at a marine laboratory in Florida or Bermuda, to study color changes in the skins of semi-tropical fishes.

Frank A. Pattie, Jr., instructor in psychology, to study the gregarious instinct in chickens through observations of their behavior when hatched in isolation.

Harlow Shapley, director of the Harvard College Observatory, to enable him to continue research on variable stars and the dimensions of the galaxy.

Derwent S. Whittlesey, assistant professor of geography, to enable him to study the chorography of a coastal locality in northern New England in order to make comparisons with the upland interior visited in 1926.

TESTIMONIAL TO DEAN KIMBALL, OF CORNELL UNIVERSITY

A TESTIMONIAL volume has been presented Professor Dexter S. Kimball, dean of the College of Engineering of Cornell University, by the Schenectady Section of the American Institute of Electrical Engineers. The presentation was made after Dean Kimball had delivered the fifth annual Steinmetz Memorial Lecture at Schenectady on March 8.

The lectureship was founded in 1925. The four previous lectures and their subjects were Dr. Michael I. Pupin, "Law, Description and Hypothesis in the Electrical Science"; Dr. Ernst J. Berg, "The Solution of Transient Phenomena by Elementary Mathematics"; Dr. Robert A. Millikan, "Spectroscopic Prediction," and Dr. Max Mason, "Substitutes for Experience."

The testimonial given Dean Kimball was in the form of a parchment book, bound in blue morocco, with a hand-tooled inscription. The fly-leaf, as well as the testimonial page, is hand-lettered and beautifully illuminated.

The inscription reads:

> In honor of Charles Proteus Steinmetz his friends and admirers have endowed the annual Steinmetz Memorial Lectures which are delivered by eminent scientists and engineers under the auspices of the Schenectady Section of the American Institute of Electrical Engineers.

The testimonial:

THIS TESTIMONIAL
IS PRESENTED TO
DEXTER SIMPSON KIMBALL
DEAN OF THE
COLLEGE OF ENGINEERING
CORNELL UNIVERSITY
WHO ON MARCH 8TH, 1929,
DELIVERED THE FIFTH ANNUAL
STEINMETZ MEMORIAL LECTURE
ON
MODERN ENGINEERING ECONOMICS

THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE thirteenth annual meeting of the Pacific Division of the American Association for the Advancement of Science is to be held at the University of California on its Berkeley campus from June 19 to 22, according to the announcement of the executive committee. Seventeen of the thirty-one societies associated with the Pacific Division have arranged sectional programs, in addition to the general program of the association.

The Pacific Division prize, an award of $100, is announced for an important scientific contribution reported at this meeting. This is the first time that this prize, announced at the Pomona College meeting last summer, will have been awarded.

Officers of the Pacific Division of the American Association for the Advancement of Science are: *President,* Walter S. Adams, Mount Wilson Observatory, Pasadena; *vice-president,* Ernest G. Martin, Stanford University; *secretary-treasurer,* Arthur G. Vestal, Stanford University; *executive committee,* S. J. Barnett, Roy E. Clausen, L. B. Loeb and J. H. Moore, University of California; J. O. Snyder, Stanford; O. F. Stafford, University of Oregon, and Bernard Benfield, consulting engineer, San Francisco.

The Southwestern Division of the American Association for the Advancement of Science will hold its session jointly with the Pacific session, this being the fourth meeting of this kind.

Professor T. D. Beckwith is chairman of the general committee on arrangements, appointed by President W. W. Campbell, of the University of California. Subcommittees on local affairs, reception and entertainment and excursions have been appointed.

SCIENTIFIC NOTES AND NEWS

THE presentation of the John Fritz medal recently awarded to President Hoover will be made officially at a dinner at the White House on April 15. The medal represents the highest award of the four great national engineering societies in mining, mechanical, electrical and civil engineering. It was awarded to President Hoover not in recognition of any single achievement but on the basis of his entire record.

DR. ARISTIDES AGRAMONTE, of Havana, the only surviving member of the yellow fever commission to Cuba, is one of those on whom congress has conferred a gold medal, carrying the award of merit and an annual pension, "for past service far above and beyond the call of duty."

THE American Institute of Mechanical Engineers has joined with the American Society of Electrical Engineers in recommending to the Institution of Civil Engineers of Great Britain that the Kelvin medal be awarded to Professor Arthur E. Kennelly, of Harvard Engineering School, for his research in fields so widely explored by the late Lord Kelvin. The award, which is given every three years, was created in 1902 to commemorate Lord Kelvin's researches in ocean telegraphy and electrical measuring devices. The Institution of Civil Engineers of Great Britain accords the American engineering societies the privilege of nominating persons to receive the award.

MANCHESTER UNIVERSITY proposes to confer an honorary degree of doctor of science upon Sir Ronald Ross in recognition of his work in the prevention of malaria. It is proposed that the degree shall be conferred at the university's commemoration of Founder's Day on May 15, which is two days after his seventy-second birthday.

THE degree of doctor of science will be conferred by the University of Dublin in July on Dr. Francis William Aston, F.R.S., of Trinity College, Cambridge.

DR. ADOLF SCHMIDT, formerly director of the meteorological magnetic observatory at Potsdam, and Dr. Hans Spemann, professor of zoology in the University of Freiburg (im Breisgau), have been elected corresponding members of the Prussian Academy of Sciences, and Dr. Edwin Schroedinger, professor of theoretical physics, has been elected to membership.

DR. MAX VON LAUE, professor of theoretical physics in the University of Berlin, and Dr. Arnold Sommerfeld, professor of theoretical physics in the University of Munich, have been elected honorary members of the Leningrad Academy of Sciences.

SEVEN members of the new Italian Academy in the section of mathematics and physical sciences have been appointed by the king of Italy as follows: Professor Filippo Bottazzi, who for many years occupied

the chair of physiology at the University of Naples and was during the war a member of the Inter-Allied Food Commission; Professor Giotto Dainelli, professor of geology and physical geography at Florence; Professor Enrico Fermi, who four years ago, when only twenty-four years of age, was appointed to the chair of pure physics in the University of Rome; Professor Nicola Parravona, dean of the faculty of science and professor of chemistry; Professor Pietro Romualdo Pirotta, professor of plant physiology, and Professor Francesco Severi, professor of calculus, all of the University of Rome, and Professor Gian Carlo Vallauro, president of the School of Naval Wireless Telegraphy.

A PRIZE of two hundred and fifty dollars offered by the Scientific Apparatus Makers of America for the best paper on instruments, other than optical instruments, to appear in the *Journal* of the Optical Society of America and Review of Scientific Instruments during 1928, has been awarded to Mr. N. E. Bonn, of the Leeds & Northrup Company of Philadelphia, for his paper on "An Improved Rosa Curve Tracer," which appeared in the September, 1928, issue. The committee of award consisted of Professor P. I. Wold, of Union College; Dr. Saul Dushman, of the General Electric Research Laboratory, and Professor L. W. McKeehan, of Yale University. A similar prize is offered for 1929.

MERRITT LYNDON FERNALD, Fisher professor of natural history (botany) at Harvard University, has been made a member of the Société Linnéenne de Lyon.

DR. OLIVER KAMM, of the research department of Parke, Davis and Company, has been elected president of the Michigan Academy of Sciences.

DR. LEONOR MICHAELIS, of the Medical School of the Johns Hopkins University, has been appointed to the staff, with the title of member, of the Rockefeller Institute for Medical Research, New York.

H. F. MURWIN, agent in charge of the work of the Bureau of Plant Industry of the U. S. Department of Agriculture on tobacco and plant nutrition in the Connecticut valley, has been appointed director of the Harrow Experiment Station at Harrow, Ontario, where he will take up his work about May 1.

JOHN B. REED, of the bureau of chemistry of the U. S. Department of Agriculture, has been appointed chemist to the District Health Department at a salary of $4,600 a year by the District Commissioners to take the place of Dr. A. V. Fuller, who died recently.

DR. HERBERT F. BERGMAN, professor of botany at the University of Hawaii since 1919, has resigned to accept a position as senior pathologist with the Bureau of Plant Industry, beginning on June 1.

DR. W. H. PIERRE, formerly of the department of agronomy of the Alabama Experiment Station, has become associate agronomist at the West Virginia Agricultural Experiment Station. Dr. Pierre will devote practically all his time to research in soils.

R. L. ADAMS, professor of farm management and agricultural economist in the experiment station at the University of California, has been appointed to the board of directors of the Federal Land Bank at Berkeley.

RALPH NEUMULLER has resigned from the United Electric Light and Power Company, effective on April 1, to become director of the new Westinghouse Lighting Institute, to be located in the Grand Central Palace, New York City, which it is expected will be opened in the early summer.

RALPH P. PERKINS has resigned his fellowship at Northwestern University to accept a position as research chemist with the Dow Chemical Co., Midland, Michigan.

DR. GORDON F. HULL, professor of physics at Dartmouth College, who is on leave of absence for the year 1928–29, worked at the University of Cambridge till the middle of December and planned to spend the following six months at the Universities of Göttingen and Berlin.

HOWEL WILLIAMS, Commonwealth fellow from England who has been studying at the University of California for the past two years, has returned from a three months' trip to Tahiti and the Society Islands where he studied the extinct volcanoes of the district.

DR. LEE S. CRANDALL has returned to New York after an expedition to New Guinea made under the auspices of the New York Zoological Society for the collection of birds.

THE Medical Society of the District of Columbia invited Dr. William Allen White, superintendent of St. Elizabeth's Hospital, to give the annual lecture of the Kober Foundation, at Georgetown University on March 25. His subject was "The Social Significance of Mental Disease."

THE fifth Ludvig Hektoen lecture of the Billings Foundation of the Institute of Medicine of Chicago was given at the City Club on March 29 by Dr. Homer F. Swift, of the Rockefeller Institute for Medical Research, New York, on "Rheumatic Fever."

The Honorable Ray Lyman Wilbur, secretary of the interior and president of Stanford University (on leave), will be the speaker at the commencement exercises of Goucher College on June 3.

A joint meeting of the Sigma Xi Alumni Association of the University of Pittsburgh and the Physical Society of Pittsburgh was addressed by Dr. F. K. Richtmyer, of Cornell University, on March 14. The subject of the address was "Secondary Phenomena in X-ray Spectra."

Herbert W. Rand, professor of zoology at Harvard University, lectured on March 15 at Iowa State College on "Evolution, Past and Future."

On March 23 Dr. A. S. Eve, professor of physics in McGill University, delivered an address before the Royal Canadian Institute on "Physical methods used in the search for ore and oil."

At a joint meeting of the American section of the Société de Chimie Industrielle, with the American Chemical Society (N. Y. section) the Society of Chemical Industry and the American Electrochemical Society, which was held in the Chemists' Club, on April 5, Dr. Felix d'Herelle, of the Pasteur Institute, now at Yale University, spoke on "Bacteriophage and Bacteriophagy"; and Dr. Camille Dreyfus, president of the Celanese Company of America, on "Celanese."

Special addresses at the sixty-first annual meeting of the Kansas Academy of Science, held at the Kansas State Agricultural College at Manhattan, will be given by Major Haig Shekerjian, of the Chemical Warfare Service, on "Chemical Warfare," at 7:30 P. M., April 25, and by Dr. Herbert M. Evans, of the University of California, on "Vitamin E" at a noon luncheon and on "The Function of the Anterior Hypophysis" at 3:30 P. M., April 26.

The Board of Regents of the University of the Philippines has established a Baker memorial professorship in the College of Agriculture in memory of Charles Fuller Baker, who was dean of the college from 1917 until his death in July, 1927. It provides for the services of a man from abroad who shall be in residence in the college for at least eight months and who will teach five hours a week.

Professor Robert M. Wenley, head of the department of philosophy at the University of Michigan since 1896, died on March 29 at the age of sixty-seven years.

Nature reports that Mrs. Arabella B. Fisher (*née* Buckley), secretary for eleven years to Sir Charles Lyell, the geologist, and author of several popular works on general science, died on February 9, aged eighty-eight years.

Commander Giovanni Roncagli, honorary secretary general to the Royal Geographical Society of Italy, died on February 1, aged seventy-two years.

The United States Civil Service Commission states that the position of chief engineer of the metallurgical division, Bureau of Mines, is vacant and that in view of the importance of this position in the field of metallurgical research the method of competition will be as follows: Instead of the usual form of civil service examination, the qualifications of candidates will be passed upon by a special board of examiners, composed of Dr. A. C. Fieldner, chief engineer, Experiment Stations Division, Bureau of Mines; Dr. F. G. Cottrell, chief of the Fixed Nitrogen Research Laboratory, Department of Agriculture; Zay Jeffries, consultant, Aluminum Company of America and General Electric Company; Dr. John Johnston, director of the Department of Research and Technology, U. S. Steel Corporation, and Dr. A. S. Ernest, examiner of the United States Civil Service Commission, who will act as chairman of the committee. For the purposes of this examination, all of these men will be examiners of the Civil Service Commission. The entrance salary is $5,600 a year. Formal applications will be received by the Civil Service Commission until May 8.

The Research Committee of the National Geographic Society has made a grant of $5,000 for the continuation of the study of old beams and timbers in the Indian pueblos of the southwest. This work has been in charge of Dr. Albert E. Douglass, of the University of Arizona.

The non-magnetic yacht *Carnegie* reported her arrival at Papeete, Tahiti, March 13. Conditions throughout the passage from Callao, Peru, were excellent. On February 16 the soundings obtained showed depths from 2,700 meters to 5,400 meters and back to 4,100 meters over a distance of 50 miles; the ocean-deep thus revealed was named "Bauer Deep." Two uncharted submarine ridges were also discovered and rapid slopes off Tatakoto and Amanu Islands were determined. On March 8 five hours were spent ashore on Amanu Island. The bottom-sample obtained at 2,100 meters on March 10 (latitude 17°6′ south, longitude 141°9′ west) contained a few fragments of black lava with no trace of ooze, indicating recent volcanic origin. The work done on this passage included: 63 determinations of magnetic declination and 17 of magnetic intensity and inclination; 17 ocean-stations, at 15 of which bottom-samples were obtained; 206 soundings; 35 pilot-balloon flights, one of which was followed to a height of over 6 miles;

9 determinations of evaporation; 4 series of atmospheric-electric observations by eye-readings, each throughout 24 hours, and 23 complete 24-hour photographic electrograms of potential gradient. The vessel left Papeete on March 20 for Apia, Western Samoa, where she is due about the end of the month. She will also make a short stop at Pago Pago, American Samoa.

The annual report of the council of the Institution of Chemical Engineers, London, shows an increase in both membership and income. According to a notice in the London *Times,* the council, it is stated, has continued to emphasize the need for more fundamental education in chemical engineering in universities and colleges, and welcomes the announcement of courses in chemical engineering, which have been arranged at King's College, London University. Gratification is also expressed that, as a result of the institution's efforts in this direction, classes are being organized by the London County Council at the Hackney Institute. The appointments bureau of the institution is reported to have had a particularly successful year. The growing demand for chemical engineers is evidenced, it is stated, by the difficulty of filling the large number of junior posts available. It has been decided to establish awards of medals in connection with the work of the institution. The first award of the Osborne Reynolds medal for the most meritorious contribution to the progress of the institution during the year has been made to Sir Alexander Gibb. Two awards of the Moulton medal to commemorate the name of the late Lord Moulton will be made for papers on chemical engineering subjects. The senior medal in gold will not be confined to members of the institution, but for the junior award only graduates and students of the institution will be eligible.

According to the British *Geographical Journal,* the Tidal Institute at the University of Liverpool and the Liverpool Observatory, Bidston, were amalgamated to form the Liverpool Observatory and Tidal Institute. It is controlled by a joint committee of the Mersey Docks and Harbour Board and of Liverpool University. Professor J. Proudman is the director, with Dr. A. T. Doodson as assistant director. This amalgamation is planned to enable the work done by both institutions in the past to be greatly extended. All communications concerning meteorological and geophysical observations, analyses and predictions of tides, etc., should be addressed to The Director, The Observatory, Birkenhead.

The Institute of Chemistry of Great Britain and Ireland has awarded the Meldola medal for 1928 to Dr. J. A. V. Butler and the Sir Edward Frankland medal and prize to Cyril Fryer.

The former Secretary of Agriculture, William M. Jardine, in a report to the House, stated that it is feasible to adopt a ten-year cooperative program for the control of predatory animals within the United States. He recommended the adoption, whenever the financial policy of the government will permit, of a ten-year control plan, calling for annual appropriations of $782,500 for control of stock-killing wild animals and $596,200 for control of rodents, during the proposed ten-year period. This would mean annual appropriations of $1,378,700 during the ten years. The annual toll taken by the stock-killing animals in the United States is estimated anywhere from $20,000,000 to $30,000,000, most of which is from depredations of coyotes. Some idea of the destructiveness of rodents may be gained from the fact that in Idaho, according to 4,037 signed statements by farmers, there would have been an annual loss of $2,087,742 from ground squirrels in farm crops on 638,971 acres if nothing had been done toward control. Midland County, Texas, alone, it is stated, records a loss of $95,000 this year from reduced cotton yield caused by rabbits. A conservative estimate of annual loss because of rat depredations in the United States would exceed $200,000,000. Secretary Jardine said that the proposed annual appropriation of $1,378,700 under the proposed ten-year period would be an increase of $812,066 over funds now available.

UNIVERSITY AND EDUCATIONAL NOTES

Legislative appropriations for the support of Kansas State Agricultural College for the two years beginning July 1, 1929, amount to $2,607,000. The appropriations include $40,000 for new equipment for scientific laboratories, $10,000 for continuing the soil survey, $10,000 for animal abortion investigations, $12,000 for soil experimental fields, $106,500 for branch experiment stations, $10,000 for a study of shipping fever among live stock and $6,000 for remodeling experimental greenhouses.

Edward S. Harkness has given $1,000,000 to the Near East College Association. The gift is conditional on the completion of the fund of $15,000,000 by July 1, and with other conditional gifts amounting to $530,000 leaves $2,500,000 to be raised.

The school of nursing of Western Reserve University, Cleveland, has received the endowment made five years ago by Mrs. Chester C. Bolton, which now amounts to $1,500,000.

Dr. Charles Sumner Howe, president of the Case School of Applied Science since 1903 and previously

professor of mathematics and astronomy, has presented his resignation effective at the close of the present college year. Dr. William E. Wickenden, director of investigation for the Society for the Promotion of Engineering Education, has been elected to succeed Dr. Howe.

DR. HERMAN G. JAMES, dean of the college of arts and sciences and dean of the graduate college of the University of Nebraska, has been elected president of the University of South Dakota, Vermillion.

ACCORDING to press despatches, Dr. Max Meyer, since 1900 professor of experimental psychology, and Dr. Harmon O. DeGraff have been dismissed from the faculty of the University of Missouri, owing, it is said, to their having assisted students in a course in sociology to prepare and distribute among the students a questionnaire on sex problems. Professor Meyer was unanimously elected president of the Southern Society of Philosophy and Psychology, in annual session at the University of Kentucky on March 30.

THE University of Chicago announces the following foreign professors as members of the faculty for the coming summer quarter: P. W. Bryan, lecturer on geography, University College, Leicester, England; Karl Bühler, professor of psychology, University of Vienna; Werner Heisenberg, professor of theoretical physics, University of Leipzig; Charles Edward Spearman, professor of psychology, University of London, and George Struve, professor of astronomy, University of Berlin.

DR. ERNEST M. HALL has been appointed professor of pathology and bacteriology in the school of medicine of the University of Southern California.

DR. MYRA M. SAMPSON has been promoted to a full professorship of zoology at Smith College and has been appointed chairman of the department.

DISCUSSION

CLASSIFICATION OF THE PLEISTOCENE OF CALIFORNIA

ONE of the great problems of North American geology is the interpretation of the Pleistocene history of the regions south of the ice sheets of the glacial epochs. Pertaining to this problem is the subject of the proper interpretation of the Pleistocene history of our southern border regions, including those of the deposits along the Texas and California coasts and of the origin and denudation of the intervening highland regions between them. The problems are perhaps too great for any single observer to solve, and their ultimate interpretation depends upon the compilation of many observations already made or which are to come.

Many contributions to the knowledge of the Pleistocene epoch have already been made in Southern California. No one can overlook the monumental work of the Arnolds, father and son. This work up to date, however, has been largely paleontologic. The physiographic aspects and the study of continental deposits, which, in my opinion, are of equal importance as means of interpretation, have as yet received but little consideration. The stratigraphic section, founded upon paleontology, for which the term Wilmington group may be appropriately used, has hitherto included the Lower San Pedro, Upper San Pedro and Cerritos stages of Arnold, or their equivalents.

It has generally been assumed that this group of strata with marine invertebrate fossils represented the totality of the Pleistocene time. Although knowledge has existed of the remarkable Pleistocene invertebrate fossils of the La Brea pits, no well-defined means has been presented for locating their position in the Pleistocene time column.

In recent publications I have called attention to the fact that a line of hills between the Balboa and Westwood hills constituted a mountain range to which I applied the term Dominguez Range, and which perhaps is one of the newest ranges in our country. The physiographic evidence is that this range was upfolded and the alternating valleys downwarped in the latter half of Pleistocene time. Inasmuch as the strata containing marine invertebrates of the Wilmington group are folded up into the structure of the hills which compose this range, it is evident that they must represent time subdivisions prior to the origin of the range. The fact that the La Brea vertebrate fossils occur in formations which were later deposited in the structural trough made by this upfolding is proof that the age of the fauna is later than that of the Wilmington group and the beginning of the Dominguez Range epoch of folding. Thus it is that the physiographic and structural history decidedly proves that the Wilmington group of strata originated before the time of the Dominguez folding and therefore must represent the earlier half of Pleistocene time, instead of the whole, as hitherto inferred.

If these deductions be true, then the latter half of the Pleistocene should be represented by land conditions in Southern California and we should seek elsewhere than in the marine fauna for the records

of this hitherto unrecognized and later stage of the Pleistocene epoch. Such a record is profusely represented in the terraced coasts and stream valleys, the changes in the stream patterns, the fault systems and abundant continental deposits on the interior margin or landward side of the Dominguez range. The marine deposits which formerly bordered the coastward side of the uplift recorded by the range have been effaced by subsidence and regression of the sea margin. Grosser division of the Pleistocene epoch into Earlier and Later Pleistocene stages, the latter including the Wilmington group, is herewith suggested.

ROBERT T. HILL

LOS ANGELES, CALIF.,
FEBRUARY 4, 1929

MEIER-SEASHORE ART JUDGMENT TEST

THE appearance of this test book marks the introduction of scientific procedure into a new field, namely, that of analysis and measurement of art talent. In principle, it embodies some of the features of objective measurement which have developed in the psychology of musical talent in the Iowa laboratory. It consists in the development of laboratory principles for the control and recording of art judgment and furnishes a fundamental technique by means of which the measurements may be made for countless purposes in the scientific study of art principles and art talent.

Hitherto numerous efforts have been made by the method of production and by the method of paired comparison under uncontrolled conditions. There is always a place for the method of production in the study of art; but the method here introduced gives a very much more generally available tool which conforms to the requirements of rigid control and systematic variation of factors to be observed. The two fundamental principles embodied in this procedure are, first, that when two complex objects or situations are presented for judgment as to preference they shall differ only in one respect, and this feature shall be clearly indicated in the instructions and understood by the person who makes the judgment. The second principle is that the feature varied and controlled for the purpose of experiment shall appear in its full setting in the picture as a whole. For example, if we are comparing two landscapes, one of them is a faithful copy of the original, the other is an equally faithful copy of the original, but with a substitution of one changed element, let us say the position of a human figure in the foreground which affects the principle of balance. In all other respects the two pictures are the same. The question which the person tested has to answer is, "In whic of the two pictures is the position of the man th better?" By this type of procedure it is evident tha any of the principles of art may be presented in end less variety for objective study.

The test book, now placed on the market[1] accom panied by directions and test blanks, has been pe fected under a grant to Dr. Meier from the Carnegi Corporation. It consists of 125 pairs of pictures pre sented in an attractive form and beautifully printe by one of the new processes. A single book may b used in testing as many cases as can be handled befor the book is mutilated or soiled. The test is self administrative. Having a set of books for a clas room, an entire class may be tested at one time; if set is not available, a single copy may be passe around so that each pupil has approximately one hou in which to make a record. Norms are being pub lished. The present book has been standardize chiefly with reference to the eighth grade in th public schools; but with suitable precaution, it ca be used within a range of several years both abov and below that age.

CARL E. SEASHORE

UNIVERSITY OF IOWA

THE PROBLEM OF THE INTERACTION O RADIATION AND THE ELECTRON

IN the course of some thermodynamical investig tions the writer was led to deduce that the electro possesses the following properties: (a) It may po sess internal energy apart from kinetic energy. (b It can radiate in two entirely different ways, vi (1) on undergoing acceleration; (2) on emitting part of its internal energy as radiation, which is n necessarily connected with its motion. (c) The su rounding radiation gradually slows down its motio which is attended by an increase in internal energ (d) The force acting upon it when placed in a electric field depends on its internal energy, in general way decreases with it. It may therefo happen that under certain conditions it does n possess any electric field at all.

A paper on this subject was read at the Ne York meeting of the American Association for th Advancement of Science, based on investigations co tained in several papers in the course of publicatio The results cited (this is not a new theory) will n doubt strike most readers as almost amazing in th light of our present knowledge of electricity, and n doubt the thought will arise that there must be som thing wrong in the deductions. The writer would b

[1] Published by the Bureau of Education Research, Un versity of Iowa, at a nominal price of $1.00 per book, i the interest of the extension of scientific service in a

inclined to think so too if he had not succeeded in proving them thermodynamically along several different lines.

By means of these results and the laws of conservation of energy and momentum, and that radiation is *emitted* in quanta (the nature of the process of emission of radiation does not seem to be determined by thermodynamics), the various phenomena depending on the interaction of radiation and the electron may be explained—at least there is nothing the writer has not, so far, brought into line. For example, all the inherent difficulties of the Bohr atom, and its antagonism to the Lewis, Langmuir atom, completely disappear. The results thus furnish the solution of a problem in physics and chemistry that has absorbed the attention of scientists for the last thirty years.

R. D. Kleeman

Schenectady, N. Y.

MOSAIC OF SUGAR-CANE IN PERU

During the past year and a half, since the establishment of the agricultural experiment station of the National Agrarian Society of Peru, a survey has been made of the principal sugar-cane-growing sections of the country for the purpose of determining the presence and distribution of the mosaic disease of that crop. Heretofore this disease has not been reported from Peru.

In this survey visits have been made to all of the valleys of the coast where sugar-cane is of importance, and to three valleys of the interior, east of the Andes mountains. Up to the present time mosaic has been found in sugar-cane in only one valley, the Carabayllo, near Lima. The disease is generally distributed on the haciendas of this valley, the infection varying from less than one per cent. to more than 90 per cent. The counts made have not shown more than 15 per cent. infection with the exception of one hacienda, and fortunately the growing of cane is to be discontinued there this year. The varieties affected include Bourbon or white cane, Louisiana Purple and some varieties of Barbados.

The mosaic was introduced into commercial cane fields in the Lima region about eight years ago and became distributed before the disease was known here. The original source of the disease is said to have been stalks of cane which were introduced from Argentina.

E. V. Abbott

Estación Experimental Agrícola,
Lima, Peru

The discovery of the mosaic disease of sugar-cane in Peru makes desirable a statement regarding the aphids present in the cane fields of this country.

Although not previously reported, the common yellow aphis of sugar-cane, *Sipha flava* Forbes, is present on sugar-cane throughout the northern valleys of Peru, being most abundant on the Bourbon or white cane, and also being noted on lemon grass, but in no observed case being sufficiently common to cause appreciable damage to the crop. As it occurs on the tips of the leaves, it can in no way be connected with the transmission of the virus of the mosaic disease of sugar-cane.

The corn aphid, *Aphis maidis* Fitch, has been noted on various grasses in cane fields in all parts of Peru, and also on the large grass locally known as "carrizo," *Arundo donax*, which commonly grows along ditch banks in the cane fields. The omnipresence of this aphid, the known vector of mosaic disease of sugar-cane, emphasizes the importance of the prompt elimination of all stools of infected cane, and the inadequacy and futility of the steps, already being enforced on some plantations, to prohibit the growing of corn. Despite the abundance of this aphid on corn, and the apparent indication of corn as its normal host by both its common and scientific names, yet it is most distinctly not the individuals occurring on corn that are primarily instrumental in transmitting the mosaic disease of sugar-cane, but rather those which occur on grasses in the cane fields and are forced to attempt to obtain nourishment from the cane when the aerial portions of these grasses are destroyed by hoeing and cultivation of the young cane.

George N. Wolcott

Estación Experimental Agrícola,
Lima, Peru

QUOTATIONS

CONGRESS HONORS THE YELLOW FEVER COMMISSION

The work of Walter Reed and his associates of the Yellow Fever Commission has now been officially recognized by the congress of the United States and approved by the president. The twenty-two members of the military establishment who participated in the experimental investigation of yellow fever in Cuba are to constitute a roll of honor that shall be published annually in the *Army Register*. In further recognition of their public service, gold medals will be presented to those who are living and posthumously to representatives of those who have died. Congress provided also a pension of $125 a month to the sixteen living members and to the widow of one of the soldiers. The everlasting benefit resulting from the courage of these men has received consideration on

previous occasions, and from time to time aid has been extended to some of those in need. The report of these experiments published for the use of the Senate in 1911 is one of the most interesting volumes in American medicine. However, these men have not been honored by congress alone. The American Medical Association at the Saratoga session in 1902 sent the members of the Yellow Fever Commission a vote of thanks and resolved that the far-reaching beneficence of their discovery was second in magnitude only to that of Jenner's discovery of vaccination. Scientific societies throughout the country paid similar respects; the Virginia state medical society has made the birthplace of Reed a national shrine, and monumental structures have been named in honor of other members.

These are the Americans who risked their lives to help discover the method of transmission of a fatal epidemic disease. They volunteered to be injected with blood from patients dying of yellow fever or to be bitten by infected mosquitoes, to sleep in beds in which patients died and to wear the clothes of patients who died. Thus they helped to drive yellow fever almost from the face of the earth. Our own land had previously been invaded at least ninety-five times with a loss of not less than a hundred thousand lives. It seems incredible in the light of present knowledge that epidemics of yellow fever have taken 3,454 lives in New York, 10,038 in Philadelphia, 4,565 in Charleston, 7,759 in Memphis, 2,000 in Norfolk and 41,348 in New Orleans, besides sweeping through Baltimore and many smaller cities. In those days people fled from their homes, for nobody knew whence or how the scourge came.

When the U. S. Army Commission was sent to Cuba in 1900 to investigate the cause, yellow fever was still taking the lives of American soldiers, although three years before Sanarelli believed that he had discovered the cause. Major Reed, the chairman, knew that Sanarelli's work had been accepted by some American investigators. The commission therefore gave its entire time at first to a search for *Bacillus icteroides* and after a study of twenty-one cases during life and eleven necropsies concluded that it bore no causative relation to the disease. Attention was then given to Finlay's theory that yellow fever was transmitted by mosquitoes. A camp was built near Havana, the buildings being screened so that mosquitoes could be kept in or out, as desired. The work was organized so that every step was controlled. Here the volunteers whom congress has honored offered their lives and lived for weeks in the face of death. Some of these men did not contract yellow fever but twenty-two cases were produced in the course of the experiments. All except Dr. Jesse W. Lazear recovered. It was proved that yellow fever is transmitted by *Stegomyia fasciata,* that it can be transmitted by the injection of blood from yellow-fever patients and that it is not transmitted by exposure to fomites.

In the further recognition of this achievement and in honoring and assisting these men, congress has reflected great credit on the whole country. The world has received the benefaction they bestowed.—*The Journal of the American Medical Association.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

SOME USEFUL PETROGRAPHIC METHODS

"A LOCATION Finder for Microscopes" described in the February 15 issue seems to me a rather cumbersome and complicated method of doing what we have been doing for years with an ordinary mechanical stage on a (Leitz) petrographic microscope. The slide always fits into the stage in a fixed position relative to the optic axis of the microscope, and the coordinates of the object in view are simply read off and recorded, as 15/7, for example.

While on the subject, it may interest users of petrographic microscopes to learn of a method of determining refractive indices in thin sections, powders, etc., which has entirely superseded in this laboratory the Becke Line method, shading the mirror with a card, etc. The object is viewed with a No. 3 objective (Leitz microscope) with the polarizer in and the condenser cut. The analyzer is slowly moved in, and the boundary between the adjacent mineral grains, or the mineral and immersion liquid, becomes sharply illuminated or shaded, as the relative index is less or greater. The method is exceedingly delicate; and the optical theory will be evident on brief consideration of the passage of light in the optical system.

Another small item which has been found useful is in the use of the pinhole and the oil-immersion ($^1/_{12}$) lens in securing interference figures of very small grains. It has been found that with the ocular removed, as is necessary for securing sharp definition, the Bertand lens makes a quite satisfactory provisional ocular, and may be used for orthoscopic vision while centering, etc., for conoscopic.

CHARLES MILTON

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RECORDING BY PERFORATING

PHYSIOLOGISTS and psychologists may be interested in a new principle of accurate recording which has proved to be practical, convenient and inexpensive.

A pin was attached at right angles to the prong of a 100 dv. tuning-fork, and its tip vibrated in a cork. By pulling a strip of adding-machine paper over the cork while the tuning-fork was in operation, the fork punched timing holes as accurately as it ever traced a curve. An electric bell, with the gong removed, and with a pin on its arm, likewise will give a series of perforations for as long as the circuit is closed. Thus any method of closing the circuit through the electric bell for an instant or for long times will give a record.

Mr. Joe Alexander, a graduate student in the psychology of athletics, has applied this principle to a study of reaction and total time in running. He records the firing of the gun, the start and the finish, by making contacts which momentarily close the circuit of the electric bell interrupter. The 100 dv. fork gives him his finer measures, and a one-second timer the grosser. He can record all six runners in the 100-yard dash at the same time.

This basic method of recording by perforating may be used to replace many types of fountain pen and pencil recordings, and may especially be used in reaction time work. There are no adjustments or refillings of any kind to the recording instruments, and our present device is relatively fool-proof.

MILTON METFESSEL

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SPECIAL ARTICLES

THE STIMULATION OF METABOLISM BY ALCOHOL

THE foods serve several functions in the body. One of the functions is to be oxidized to give rise to heat and energy, and another to increase metabolism, or oxidation. The animal body is continually producing heat and giving it off to the surrounding air. Previous to the time of Lavoisier (1780) it was a most difficult problem to explain this heat production by an animal. Lavoisier solved the problem when he showed that the heat of the body is derived from the oxidation of the food materials.[1] How this oxidation is brought about in the body seems to be as perplexing now as was the problem of how heat was produced in the body before the time of Lavoisier. Lavoisier also showed that the ingestion of the food increased oxidation and heat production. Rubner[2] found that the ingestion of protein increased metabolism more than sugar or fat. Lusk found that the amino acids increased heat production, and he attributed the stimulating effect of proteins to the amino acids resulting from the digestion of the proteins.[3] Later, however, he attributed it to the organic acids resulting from the deaminization of the amino acids.[4]

It is already recognized that alcohol can serve at least one function of the foods, namely, that of being oxidized in the body to give rise to heat. In fact, alcohol is more easily oxidized than ordinary foodstuffs, and for this reason it is used in critical periods of sickness and in weakened conditions of the body. The object of this investigation was to determine if alcohol can also serve another function of the foods, namely, that of stimulating metabolism, or more specifically, sugar metabolism.

The respiratory quotient is the index usually used to the amount of sugar metabolized in the body, a rise in the quotient indicating an increase in sugar metabolism; and a fall, a decrease in sugar metabolism. In this investigation sugar utilization, as well as the effect of alcohol and the foodstuffs on this utilization, was determined directly. This was done by adding these materials to sugar solutions in which were placed goldfish and making sugar determinations from time to time. A mixture of glycerole with equal portions of sodium palmitate, stearate and oleate was used for the fat. The alcohol used was ethyl alcohol. Instead of protein a mixture of equal portions of the following amino acids was used: glycine, dl-leucine, dl-valine, d-glutamic acid, dl-isoleucine, l-tryptophane, l-cystine, l-tyrosine, l-leucine, dl-alanine, arginine, dl-phenylalanine and l-aspartic acid. Three cubic centimeters of alcohol were used. One cubic centimeter was added at the beginning of the experiment and one half cc was added subsequently at intervals of five hours until 3 cc in all had been added. One hundred mgs of the mixture of fatty acids and glycerole as well as a hundred mgs of a mixture of the amino acids were used.

The following is the description of a typical experiment. Five hundred cubic centimeters of 0.1 per cent. dextrose solution were prepared, sterilized and divided into four portions of 125 cc. Each portion was introduced into a 200 cc beaker. Two goldfish of approximately the same size and with a combined weight of approximately 5 gms were introduced into each beaker. Air was bubbled through the sugar solutions to insure an adequate supply of oxygen to the

[1] A. L. Lavoisier, "Memoire sur la Chaleur," Mem. Acad. Sc., 355–424. 1780.

[2] M. Rubner, "Die Gesetze des Erergieverbrauchs bei der Ernährung," 322–323. 1902.

[3] G. Lusk, "The Influence of the Ingestion of Amino Acids Upon Metabolism," *Journal of Biological Chemistry,* 13: 155–183. 1912–1913.

[4] G. Lusk, "An Investigation into the Causes of the Specific Dynamic Action of the Foodstuffs," *Journal of Biological Chemistry,* 20: 555–617. 1915.

fish. Into one of the beakers, 100 mgs of the mixture of the amino acids were introduced; into another, 100 mgs of the mixture of the fatty acids and glycerole; to the third, 1 cc of 100 per cent. ethyl alcohol was added, and the fourth and fifth beakers to which nothing was added served for controls. Small amounts of the sugar solutions were removed immediately from each beaker and sugar determinations were made according to the method of Benedict. Sugar determinations were also made again after thirty hours at the end of the experiment. Six series of such experiments were made and the following is the average for the six experiments. The average amount of sugar used by the controls in thirty hours was 36 per cent.; the fish to which the alcohol was added used 57 per cent.; those to which the fatty acids and glycerole were added, 58 per cent., and the fish to which the amino acids were added used 62 per cent. of the sugar. By comparing these figures it will be seen that alcohol increased sugar utilization almost as much as the fat and protein or the amino acids. It should be stated that the increase in the sugar utilization produced by these substances was fairly uniform and constant in all the experiments.

SUMMARY

(1) The effect of ethyl alcohol, fat and protein, or the amino acids, on sugar metabolism was determined directly.

(2) It was found that alcohol stimulated sugar metabolism almost as much as fat and protein.

(3) From this it is concluded that alcohol, in addition to serving as a source of heat and energy, may also serve another function of the foodstuffs, namely, that of stimulating metabolism.

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D. J. Verda,
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A RELATION BETWEEN THE MEAN DISTANCES OF THE PLANETS FROM THE SUN

In 1772 Bode drew the attention of the scientific world to an empirical law, previously discovered by Titius, relating the mean distances of the planets from the sun. If we write the following number series: 0, 3, 6, 12, 24, 48, 96, 192, 384, and add 4 to each member of the series we obtain the following numbers, which are very nearly proportional to the mean distances of the planets from the sun: 4, 7, 10, 16, 28, 52, 100, 196, 388.

The first term of this series, which corresponds to the planet Mercury, does not belong to the series but should have the value 5.5 instead of 4. Moreover, the actual distance of Neptune is less than four fifths the expected distance. Nevertheless, Bode's law has served a useful purpose inasmuch as it suggested the existence of an unknown planet in the fifth position and thereby led to the discovery of the host of asteroids.

The writer has discovered another simple relation between the planetary distances, and so far as he is aware this relation has not been reported hitherto. It suggests the possibility that the orbits of the planets may be "quantized" somewhat after the manner of the electronic orbits in the Bohr atom. For this reason it may prove to have some theoretical importance.

The mean distances of the planets from the sun are proportional to the squares of simple integral numbers. The four innermost planets are represented by four successive integers, *viz.*, 3, 4, 5 and 6. The space between Mars and the average mean distance of the asteroids (taken as 2.7 astronomical units) corresponds to a difference of 2 between the corresponding integers, that between the asteroids and Jupiter to a difference of 3, that between Jupiter and Saturn to a difference of 4, that between Saturn and Uranus to a difference of 6, and that between Uranus and Neptune to a second difference of 6. The last two planets do not fit into the law quite as well as the others, but on the whole the agreement is good, and can scarcely be accidental.

The following table gives the data upon which the preceding statements are based. The numbers given in the third column of the table are obtained by dividing the mean distances in astronomical units by 0.0425, and extracting the square roots of the quotients.

TABLE

Planet	Distance from sun in astronomical units	Square root of comparative distance	Nearest integer	Percentage deviation
Mercury	0.3871	3.018	3	+0.60
Venus	0.7233	4.125	4	+3.13
Earth	1.0000	4.851	5	−2.98
Mars	1.5237	5.988	6	−0.20
Planetoids	2.7(?)	7.97	8	−0.4(?)
Jupiter	5.2028	11.06	11	+0.59
Saturn	9.5388	14.98	15	−0.13
Uranus	19.1910	21.25	21	+1.19
Neptune	30.0707	26.60	27	−1.50

A. E. Caswell

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